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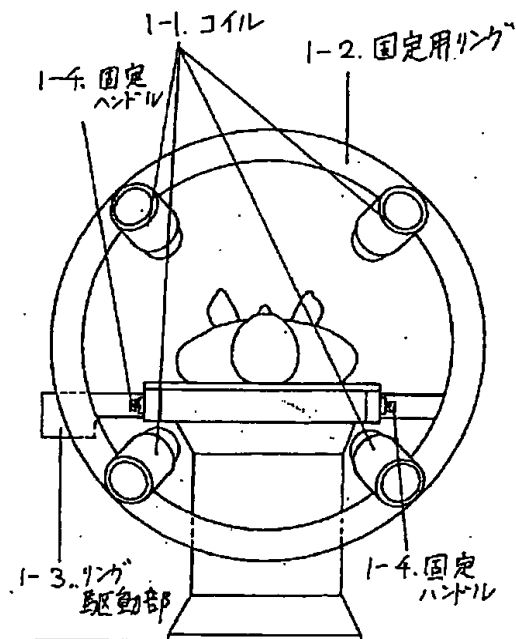
最終頁に続く

(54) 【発明の名称】 医療用総合磁気装置

(57) 【要約】

【課題】 磁気を応用した医療器材を、小型化、高効率化、低消費電力化、低漏れ磁束化し、また従来の医療器具と併用しつつ、実際の医療の場において利用可能とする。

【解決手段】 少なくとも一個以上の空芯または鉄芯コイルを、平面または曲面上に配置し、これを対向させた中に患者を収納し、各コイルの通電電流の強度と位相、周波数を制御して、患者体内の磁力に反応する器具を制御して医療行為を行う。またこの装置で、患者と反対側で鉄芯コイルの鉄芯と他のコイルの鉄芯とを連結し、漏れ磁束を減弱し、他の医療器具との併用を更に容易とする。



【特許請求の範囲】

【請求項1】平面または曲面上に少なくとも1個以上のコイルを配置し、このコイルを対向させるまたは単独に用い、患者の近傍に配置し、患者の体内に磁場を発生させ、体内で磁力を応用した誘導や、診断、治療を行う装置。

【請求項2】複数の鉄芯コイルを患者の周囲に配置して、鉄芯コイルの目的とする磁場を発生する反対側で、他の鉄芯コイルの鉄芯と連結することで、周囲への漏れ磁束を大幅に減少させつつ、患者体内に磁場を発生させ、患者体内で磁力を応用した誘導、診断、治療を行う装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】この発明は、少なくとも1個以上のコイルを患者の周囲に配置し、患者の体内に磁場を発生させ、また制御することで、体内に挿入した磁力に反応する器具を誘導し、またエネルギーを与えて、診断、治療などの医療行為を行う、医療用機械器具である。

【0002】

【従来の技術】体内の磁石を装着した医療器具を牽引するために、体表から磁石をあてるのみでは、有効な磁力を発生することは容易ではなく、また十分な磁力を与えることができても、距離の3乗に反比例する磁場の原理から、体内の管腔内の自由な位置にとどめて誘導することは、不可能に近く、これまで医療の場において実用化できなかった。器具の誘導が容易な平行磁場を発生するためには、大型の空芯コイルを井桁状に組み合わせ、内部に患者を収容する必要がある。しかし装置全体が巨大化するため体内の器具の位置の確認に必要なX線透視装置やCTと干渉し、またコイル自体がX線を遮るために体内の器具の位置が確認できず、有効な磁場を発生するための電力も大きく、また周囲への漏れ磁束も大きい。そのため周囲の器具への影響があり、安全性を含めて実用化が非常に難しかった。更に通常の医療行為を施行中、磁気装置の補助が必要、またその応用が手技を促進すると考えられる場合でも、装置の汎用性がないため、検査室、検査手技、患者、また検査の一時期などの必要に応じた、容易かつ一時的な適用が難しかった。以上のような理由から、磁気装置の医療の場での実際の応用は、現在まで不可能であった。

【0003】

【発明が解決しようとする課題】磁気を応用した医療器材を、従来の医療器具との併用を可能又は容易とし、高度な誘導を含む磁気の有効利用を行う。また目的に応じて、装置の小型化、高効率化、低消費電力化、低漏れ磁束化を行い、実際の医療での汎用性を向上して実用可能な医療装置とする。

【0004】

【課題を解決するための手段】少なくとも1個以上の空芯又は鉄芯コイルを、その間隔を目的にあわせて患者の体外に配置して、各コイルの通電電流の強度と位相、周波数を制御することにより、目的に応じた強度と方向、作用の磁場を患者体内に発生させ、体内に挿入した磁力に反応する器具の誘導や、診断、治療を行う。

(1)平面または曲面上に少なくとも1個以上のコイルを配置し、このコイルを対向させるまたは単独に用い、収容した患者の体内に磁場を発生させる。

(2)鉄芯コイルの目的とする磁場を発生する反対側で、他の鉄芯コイルの鉄芯と連結して、周囲への漏れ磁束を減じる。

以上のような基本的コイル配列および構造を持った装置を、単独または複合して用いることで、患者体内の磁気反応する器材を介して医療行為を行う。

【0005】

【発明の実施の形態】図1、2の様に、単一平面内に4個のコイル(1-1、2-1)を固定用リング(1-2、2-2)上に配列し、中心を空洞としたものを基本器具(リングA)として、2個を対向させ、2つのリングAの穴を通して患者を収容する。それぞれのコイルの組み合わせと間隔、角度を調節して、通電電流、電圧、極性、周波数、波形を制御して、患者体内に磁場を形成して、体内に挿入した器具の誘導を行い、診断、治療といった、医療行為を行う。リングAの間隔をとること、CT装置や、X線透視装置との干渉を防止する。リングA内のコイル数は目的にあわせて設定し、また複数の中から使用するものを選択することも可能である。たとえば図1、2の4個のコイルのうち、対向する2個のみをコイルとし、残りを1組のX線透視装置とすれば、磁力による誘導のX線透視での確認と操作が容易となり、またこの形の装置は、CアームX線透視装置のアームを延長し、コイルを装備することで製作できるため普及が容易である。平面に限らずに必要に応じて曲面上に配置することも可能である。コイル数が多ければ、より高度な制御が可能であり、反対に単純な制御であれば、1個のコイルでも可能である。またリングAを1個単独に使用して、単純な制御を行うことも可能で、リングAを追加するなどリングAを3個以上使用することや、目的に適したコイルを補助コイルとして単独、又複数で追加することで、更に高度な制御を行う。リングAの様にリング状、枠状としなくても、複数、又は単独のコイルを、患者周囲にたとえば自在アームを使用して配置し、それぞれのコイルの組み合わせと間隔、角度を調節し、通電電流、電圧、極性、周波数、波形を制御して、患者体内に磁場を形成して、体内に挿入した器具の誘導を行い、診断、治療といった、医療行為を行う。間隔を十分にとること、CT装置や、X線透視装置との干渉を防止する。コイルに磁性体を組み合わせることで、鉄芯コイルとすれば、磁場強度は5~10倍となり、高効率

化、低消費電力化が可能である。また複数のコイルの鉄芯外側を磁性体で連結した図3、4のような装置においては、患者医療行為を行う外側で鉄芯が連結されるため、周囲に対する漏れ磁束を大幅に減少させることが可能となり、結果として装置全体、部屋全体の磁気シールドを行わなくても漏れ磁束は100分の1程度まで減少する。磁気シールドを追加すれば、1000分の1～10000分の1まで漏れ磁束は低下し、地磁気レベルまで低下させることが可能である。医療行為の種類、目的に応じて、連結する鉄芯コイルの組み合わせを選択することで、制御能、磁場強度が向上する。例えば図5、6の様に、対向するコイルを磁性体で連結することで、一組となり制御されるコイルの組数が増えるため、それぞれを単独に制御を行うことで、患者用の空間を十分確保して、高い磁場強度、制御能、操作性の向上が可能である。図7、8のように、鉄芯コイルの鉄芯をCリング状として、その磁極を患者に向け、患者の周囲に少なくとも一個以上を配置することで、X線透視装置等の装置を併用しつつ、患者周囲に充分な空間が確保されることにより、鉄芯コイルの存在によって医療行為が障害されずに施行可能である。また患者の体軸方向に強い磁場を発生させることが可能であり、磁気シールドを行うことで、漏れ磁束を減少させ通常の医療器具の使用が可能となる。C型アームを単独に用いて患者を収容すれば、一軸方向への磁場を形成することが可能で、その制御およびC型磁気アームの角度、位置の調整によって、三次元的な磁場の形成が可能である。簡易な構造であるため、Cリング状の鉄芯コイルを支持装置に取り付け、回転、上下、伸縮を可能とした図9、10のごときポータブル磁界発生装置では、既存の医療器具、患者の状態、医療手技の種類、タイミングに応じて、自由に磁気装置を使

$$R_m = L_1 / (\mu_0 \cdot \mu \cdot S_1) + L_2 / (\mu_0 \cdot S_2) \quad (2)$$

これらより、ヨーク、空隙部分に発生する磁束 ϕ は、 $\phi = V_m / R_m = Ni / R_m \quad (3)$

と計算できる。ゆえに、空隙部分に発生する磁界 H は $H = \phi / (\mu_0 \cdot S_2) \quad (4)$

であるから、 ϕ に(2)、(3)式を代入して、以下のように計算できる。

$$H = \frac{Ni}{\frac{L_1}{\mu_0 \mu S_1} + \frac{L_2}{\mu_0 S_2}} \times \frac{1}{\mu_0 S_2}$$

実際に、C型ヨークの長さ L_1 を5m、空隙部(磁界発生部)長さ L_2 を30cmとした場合、C型ヨークが円

*用した、医療行為が可能となる。また磁気シールドを施せば、地磁気レベルまで漏れ磁束を軽減でき、磁気装置の医療領域における幅広い適応が可能である。鉄芯コイルを使用することによって、その鉄芯を例えば、コイル内で、ヨークが自由に移動、伸縮可能にし、必要時にたとえば固定ネジで固定することで、図11、12の様に伸縮構造とすれば、患者体内に発生させる磁場の強度、範囲を制御しつつ、併用器具、患者、目的などに対する汎用性を向上することが可能である。また伸縮機構を、磁力を発生するヨークを、別の筒状の磁性体で収容した図13、14の様にすることで、周囲への漏れ磁束を更に軽減し、また周囲機材や医療関係者との干渉を減じ、漏れ磁束を更に低減する事が可能である。また蝶番構造でコイルをささえる図15の様なアーム型とすれば、患者に対してその距離や位置の調節もより自由度が大きく、自在アームとして患者周囲の目的の位置に目的のコイルを配置することもできる。Cリング状の鉄芯コイルを用いた、図16のごとき磁界発生装置の磁力は、以下のごとく計算される。この際、C型の磁性体ヨークにNターンの励磁巻線を装着し、電流 i で励磁するものとする。C型ヨークの磁路長を L_1 とし、磁界が発生する空隙部分の長さを L_2 、ヨークの断面積を S_1 、空隙部分の断面積を S_2 、ヨークの比透磁率を μ とする。磁気回路の考えにおいて、起磁力 V_m と磁束 ϕ 、磁気抵抗(リラクタンス) R_m の関係は、 $V_m = \phi \cdot R_m \quad (1)$

となるので、発生磁束 ϕ は起磁力 V_m と磁気抵抗 R_m から算出できる。Nターンの巻線に電流 i を流しているので、起磁力は $V_m = Ni$ であり、磁気抵抗はヨーク部分と空隙部分とにわけて下記のように算出される。ただしここで、 μ_0 は真空の透磁率である。弧であるとして、その直径は約1.6mである。ヨークの断面積を、50cm角(0.25m²)とする。ここに1200ターンのコイルを巻いて100Aの電流を流すと、発生磁界は約40kA/m(=約5kOe)である。この磁界が、細径のガイドワイヤーに装着可能な1mm×1mm×3mmの角柱状希土類磁石に発生させる磁気トルクは、約12g・cmとなる。太径のガイドワイヤーに装着可能な2.5mm×2.5mm×10mmの角柱希土類磁石では、その約20倍の磁気トルクが発生し、医療操作に十分な磁気トルクを発生させる事が可能である。

計算条件			計算結果	
磁界計算	記号			
ヨーク磁路長(m)	L_y	5		
空隙長(m)	L_i	0.3	磁界(A/m)	397614.3141
ヨーク比透磁率	μ	1000	磁界(Oe)	4994.035785
ヨーク断面積(m ²)	S_y	0.25		
空隙断面積(m ²)	S_i	0.09		
ターン数	N	1200		
電流(A)	i	100	磁気トルク(Nm)	0.001182843
真空の透磁率(H/m)	μ_0	0.000001256	磁気トルク(kgcm)	0.011928429
			磁気トルク(gcm)	11.92842942
磁石残留磁化(T)		1		
磁石体積(m ³)		0.000000003		

L_i : 磁界が発生する空隙部分の長さ

L_y : C型ヨークの磁路長

S_y : ヨーク断面積

S_i : 空隙部分断面積

μ : ヨークの比透磁率

i : 電流

[0006]

【発明の効果】これまでのCTやX線透視装置との併用が可能となり、患者の体の大きさ、医療手技、必要な器材による当該装置への影響も少ない。磁場の強度、発生範囲も自由に設定可能で、周囲への磁力の影響を著しく低減し、地磁気レベルとすることが可能であるため、使用や導入、適応における自由度が著しく増大する。従来の医療手技においても、必要に応じて容易に磁気応用医療器材の利用が可能となる。また高効率化で低消費電力化が可能で、非常に高い磁場強度を形成することも容易である。これらを通して、これまで不可能であった医療領域における磁気駆動を含めた磁気装置の、実的な適用が可能となり、新たな医療手技が開発され、更にこれまで難しかった医療手技がより容易、高精度、高効果、安全に行えるなどの高い効果がある。

【図面の簡単な説明】

【図1】単一平面内に4個のコイルを固定用リング上に配列したリングAの正面図

【図2】単一平面内に4個のコイルを固定用リング上に配列したリングAの側面図

【図3】複数のコイルの鉄芯外側を磁性体で連結した装置の正面図

【図4】複数のコイルの鉄芯外側を磁性体で連結した装置の側面図

【図5】対向した鉄芯コイルを連結した装置の側面図

【図6】対向した鉄芯コイルを連結した装置の正面図

【図7】鉄芯コイルの鉄芯をCリング状とし磁極を患者

に向けた装置の正面図

【図8】鉄芯コイルの鉄芯をCリング状とし磁極を患者

20 に向けた装置の側面図

【図9】Cリング状の鉄芯コイルを支持装置に取り付けたポータブル磁界発生装置の側面図

【図10】Cリング状の鉄芯コイルを支持装置に取り付けたポータブル磁界発生装置の正面図

【図11】コイル内のヨークを移動、伸縮可能にして固定ネジで固定した伸縮機構の断面図

【図12】コイル内のヨークを移動、伸縮可能にして固定ネジで固定した伸縮機構の正面図

30 【図13】磁力を発生するヨークを、別の筒状の磁性体で収容した伸縮機構の断面図

【図14】磁力を発生するヨークを、別の筒状の磁性体で収容した伸縮機構の正面図

【図15】蝶番構造でコイルをささえるアーム型位置調整機構

【図16】Cリング状鉄芯コイルの側面図

【符号の説明】

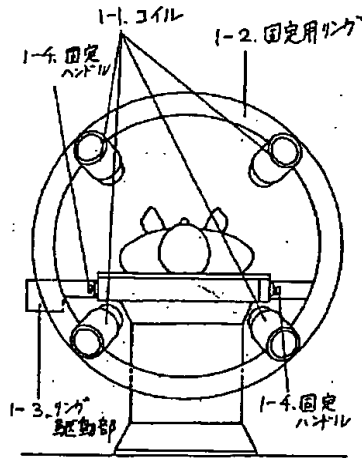
1-1	コイル	1-2	固定用リング
1-3	リング駆動部	1-4	固定ハンドル
2-1	コイル	2-2	固定用リング
2-3	リング駆動部	2-4	固定ハンドル
3-1	コイル	3-2	磁性体
4-1	コイル	4-2	磁性体
5-1	コイル	5-2	磁性体
6-1	コイル	6-2	磁性体
7-1	鉄芯コイル	8-1	鉄芯コイル
9-1	Cリング鉄芯コイル		
9-2	スパーギヤ	9-3	ビニオンギヤ
9-4	角度調整手段	9-5	スパーギヤ
9-6	ビニオンギヤ	9-7	駆動手段
9-8	スパイラルギヤ	9-9	ビニオンギヤ

- 9-10 ビニオンギヤ
 9-11 ウォーム&ウォームホイール
 9-12 ウォームホイール 9-13 ウォームギヤ
 9-14 カウンターウェイト
 10-1 Cリング状鉄芯コイル
 10-2 スパーギヤ 10-3 ビニオンギヤ
 10-4 カウンターウェイト
 10-5 スパーギヤ
 11-1 ヨーク 11-2 コイル
 11-3 磁性体 11-4 固定ネジ
 12-1 ヨーク 12-2 コイル
 12-3 磁性体 12-4 固定ネジ
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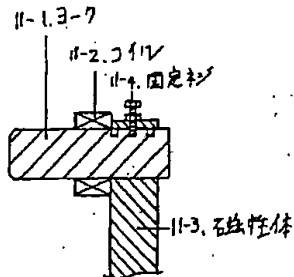
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 15-5 ウォームホイール 15-6 ウォームホイール
 15-7 ウォーム 15-8 ハンドル
 L_1 磁界が発生する空隙部分の長さ
 L_2 C型ヨークの磁路長
 S_1 ヨーク断面積
 S_2 空隙部分断面積
 μ ヨークの透磁率
 i 電流比
 N コイルの巻数

*

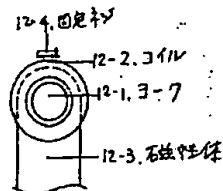
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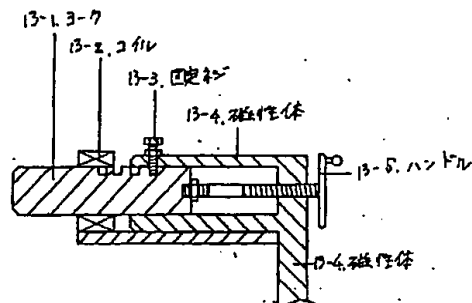
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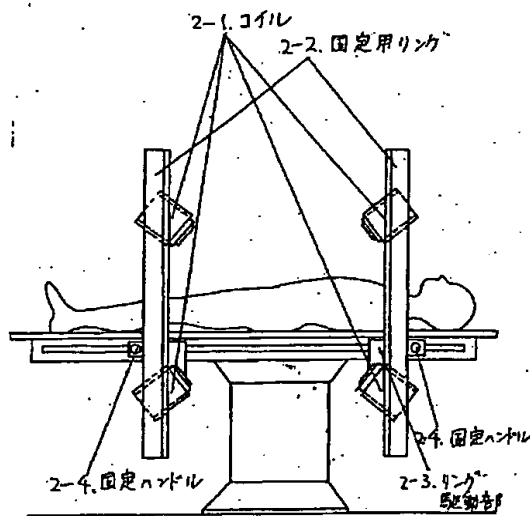
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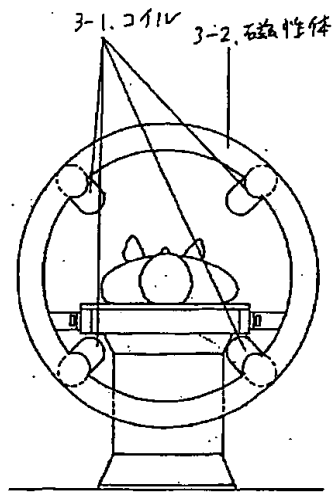
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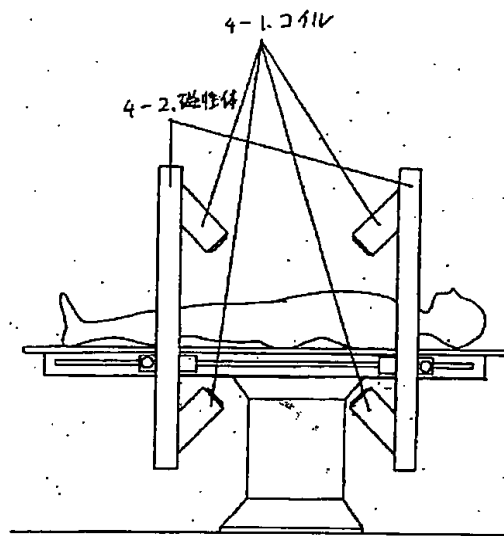
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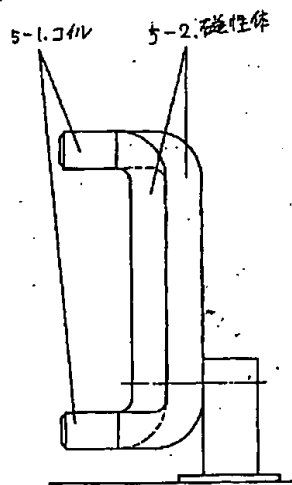
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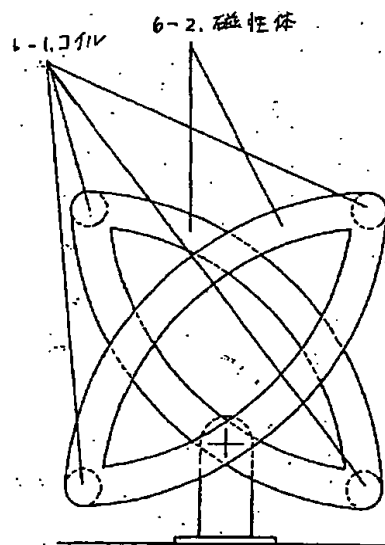
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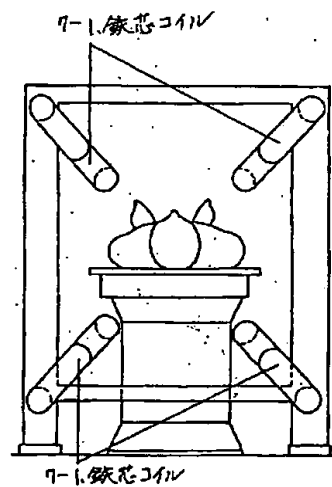
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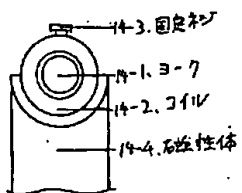
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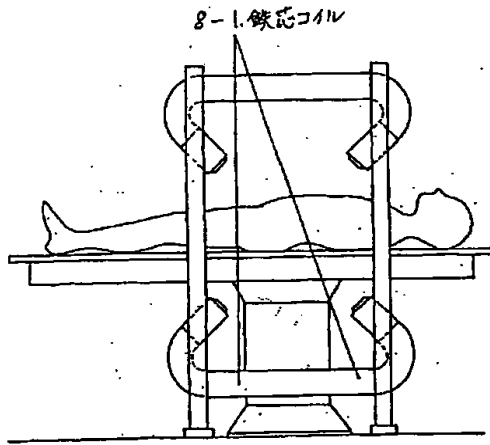
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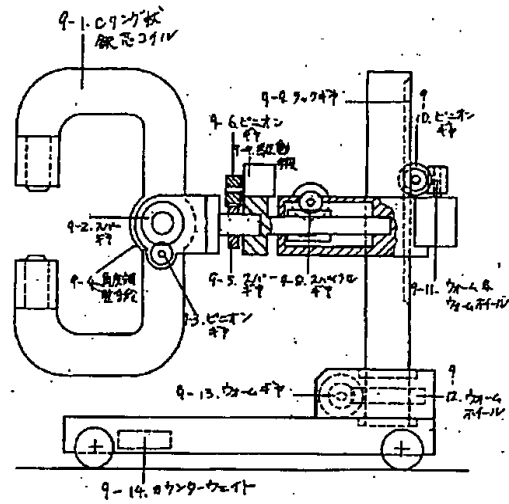
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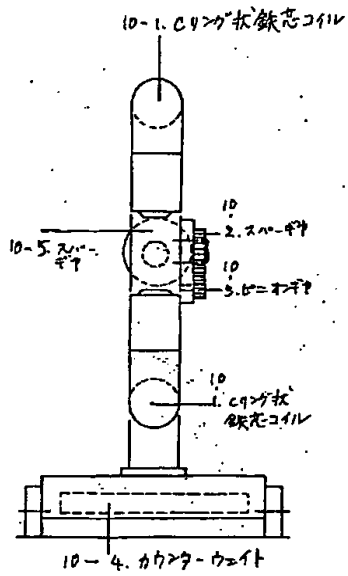
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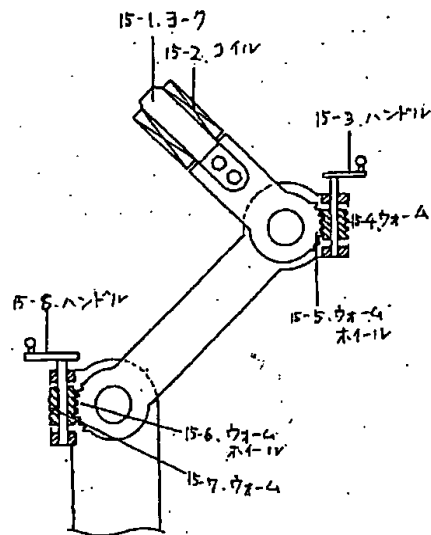
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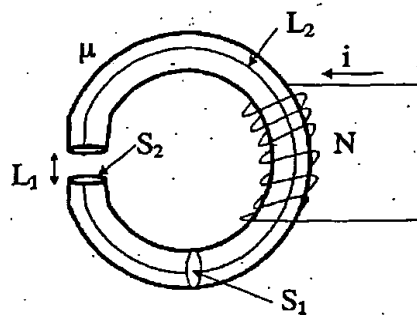
【図10】



【図15】



【図16】



フロントページの続き

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Date: September 10, 2003

Declaration

I, Michihiko Matsuba, President of Fukuyama Sangyo Honyaku Center, Ltd., of 16-3, 2-chome, Nogami-cho, Fukuyama, Japan, do solemnly and sincerely declare that I understand well both the Japanese and English languages and that the attached document in English is a full and faithful translation, of the copy of Japanese Unexamined Patent No. 2002-233575 laid open on August 20, 2002.

A handwritten signature in black ink, appearing to read 'm. matsuba' with a stylized flourish at the end.

Michihiko Matsuba

Fukuyama Sangyo Honyaku Center, Ltd.

ALL-PURPOSE MAGNETIC APPARATUS FOR MEDICAL USE

Japanese Unexamined Patent No. 2002-233575

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Inventor: Toshimitsu KOBAYASHI

Kazushi ISHIYAMA

Tadao KAKIZOE

Applicant: President of National Cancer Center

SPECIFICATION

[TITLE OF THE INVENTION] ALL-PURPOSE MAGNETIC APPARATUS FOR MEDICAL USE

[ABSTRACT]

[Object] Medical equipment that employs magnetism is adapted to achieve a reduction in size, an increase in efficiency, a reduction in power consumption, and a reduction in leakage flux, and is adapted to be usable at an actual medical site while being used together with conventional medical instruments.

[Solution Means] A medical practice is performed such that at least one air-core or iron-core coil is disposed on a plane or on a curved surface; a patient is placed in an area created

by causing the coil to face another coil; the strength, the phase, and the frequency of an electric current flowing through each coil are controlled; an instrument that reacts to a magnetic force in the interior of the patient's body is controlled. In this apparatus, the iron core of the iron-core coil and the iron core of another coil are connected together on the opposite side of the patient, and leakage flux is diminished so as to be more easily used together with other medical instruments.

[WHAT IS CLAIMED IS;]

[Claim 1] An apparatus for performing inducement, diagnosis, and treatment each of which employs a magnetic force in the interior of a body, the apparatus in which at least one coil is disposed on a plane or on a curved surface, the coil being caused to face another coil or being individually used is disposed in the vicinity of a patient, and a magnetic field is generated in the interior of the body of the patient.

[Claim 2] An apparatus for performing inducement, diagnosis, and treatment each of which employs a magnetic force in the interior of a body of a patient, the apparatus in which a plurality of iron-core coils are disposed around the patient, leakage flux that leaks to a surrounding area is greatly reduced by connection with an iron core of another iron-core coil on

an opposite side of a place where a magnetic field targeted by the iron-core coils is generated, and the magnetic field is generated in the interior of the body of the patient.

[DETAILED DESCRIPTION OF THE INVENTION]

[0001]

[Field of the Invention] This invention is an apparatus for medical use for performing a medical site, such as diagnosis or treatment, in which at least one coil is disposed around a patient, and an instrument that reacts to a magnetic force and that has been inserted into the interior of a body is induced, and energy is given by generating and controlling a magnetic field in the interior of the patient's body.

[0002]

[Prior Arts] In order to pull a medical instrument to which a magnet is attached in the body, an effective magnetic force cannot be easily generated by merely applying a magnet onto the surface of the body, and, even if a sufficient magnetic force can be given, it is next to impossible to induce it while stopping it at a free place in the tube cavity of the body from the principle that a magnetic field is inversely proportional to the cube of the distance, and it has not become possible to put it to practical use at a medical site. In order to generate a parallel magnetic field by which an instrument can

be easily induced, there has been a need to arrange large-sized air-core coils in parallel crosses and place a patient inside them. However, since the entire device becomes huge, there occurs interference with a fluoroscopic apparatus or CT that is needed to ascertain the position of the instrument in the body, and, since the coil blocks X rays, the position of the instrument in the body cannot be ascertained, and electric power to generate an effective magnetic field is also large, and leakage flux to a surrounding area is also large, and hence an influence is exerted upon instruments disposed therearound, and it has been very difficult to put it into safe practical use. Additionally, since the apparatus does not have general-purpose properties even when an aid from a magnetic apparatus is needed or its application is considered to promote manipulation during the performance of a normal medical practice, it has been difficult to make simple, temporary application that answers the requirements of an examination room, examination manipulation, a patient, a certain period of time for an examination, etc. For these reasons, it has been impossible up to the present time to actually employ it in the medical site of the magnetic apparatus.

[0003]

[Means for Solving Problems] Medical equipment that employs

magnetism is adapted to be usable or to be easily used together with conventional medical instruments, and effective utilization, which includes advanced inducement, of magnetism is carried out. Additionally, in accordance with a target, the apparatus is adapted to achieve a reduction in size, an increase in efficiency, a reduction in power consumption, and a reduction in leakage flux, and the medical apparatus is adapted to be practically usable by improving general-purpose properties in an actual medical practice.

[0004]

[Means for Solving the Problems] At least one air-core or iron-core coil is disposed outside the body of a patient while maintaining an interval between the coil and another coil so as to satisfy a target, and a magnetic field having a strength, a direction, and an operation according to the target is generated in the interior of the patient's body by controlling the strength, the phase, and the frequency of an electric current flowing through each coil; thus performing the inducement of a magnetism-reactive instrument inserted in the body, diagnosis, and treatment.

(1) At least one coil is disposed on a plane or on a curved surface, the coil is caused to face another coil or is individually used, and a magnetic field is generated in the

interior of the body of the patient placed therein.

(2) Leakage flux that leaks to a surrounding area is reduced by connection with an iron core of another iron-core coil on the opposite side of a place where a magnetic field targeted by the iron-core coils is generated. A medical practice is performed by singly or combinedly using the apparatus having the aforementioned basic coil arrangement and the structure through an instrument reactive to magnetism in the interior of the patient's body.

[0005]

[Embodiments of the Invention] As shown in Figs. 1 and 2, a basic instrument (ring A) in which four coils (1-1, 2-1) in a single plane are arranged on a fixing ring (1-2, 2-2) and its center has a cavity is caused to face another basic instrument having the same structure, and a patient is placed therein through the holes of the two rings A. An electric current flowing through the coil, voltage, polarity, frequency, and waveforms are controlled while adjusting a combination, an interval, and an angle between the coils so as to create a magnetic field in the interior of the patient's body, and an instrument inserted in the body is induced, thus performing a medical practice, such as diagnosis or treatment. Interference with a CT device or with a fluoroscopic apparatus

is prevented by creating an interval between the rings A. The number of the coils in the ring A can be determined to satisfy a target, and coils to be used can be selected from among the coils. For example, if only the opposing two of the four coils shown in Figs. 1 and 2 are used as coils, and the remains are used as a pair of fluoroscopic apparatuses, the inducement by a magnetic force can be easily ascertained and operated through the fluoroscopic apparatuses, and an apparatus shaped like this can be constructed by extending an arm of a C-arm fluoroscopic apparatus and by mounting coils thereon, and hence its spread is easily achieved. It is also possible to dispose it on a curved surface, if necessary, without being limited to the plane. If a large number of coils are provided, more advanced control can be taken, and, on the contrary, if simple control is required, the control can be achieved by only one coil. Additionally, it is also possible to perform simple control by independently using one ring A, and more advanced control is performed by adding the ring A so as to use three or more rings A or by adding a single or a plurality of auxiliary coils suitable for a target. Even if the shape of a ring or of a frame like the ring A is not assumed, a plurality of coils or a single coil is disposed around the patient by use of, for example, an adjustable arm, and a combination, an interval,

and an angle between the coils are adjusted, and thereby an electric current flowing therethrough, voltage, polarity, frequency, and waveforms are controlled, and an instrument inserted in the body is induced by creating a magnetic field in the patient's body, thus performing a medical practice such as diagnosis or treatment. Interference with a CT device or a fluoroscopic apparatus is prevented by taking a sufficient interval. If an iron-core coil is formed by incorporation of a magnetic substance with the coil, the strength of the magnetic field is made 5 to 10 times as great, and an increase in efficiency and a reduction in power consumption can be achieved. Additionally, in an apparatus shown in Figs. 3 and 4 in which the outsides of the iron cores of a plurality of coils are connected by magnetic substances, the iron cores are connected outside a place where the patient undergoes a medical practice, and therefore leakage flux that leaks to a surrounding area can be greatly reduced, and, as a result, the leakage flux is reduced to about 1/100 even if the entire apparatus and the entire room are not subjected to magnetic shielding. If a magnetic shield is added, the leakage flux will be reduced to 1/1000-1/10000, and can be reduced to a geomagnetic level. Controllability and magnetic field strength are improved by selecting a combination of connected iron-core coils in

accordance with the kind of and the target of a medical practice. A coil couple is created by connecting coils facing each other together by a magnetic substance as shown in, for example, Figs. 5 and 6, and the number of coil couples is increased, and therefore a space for the patient is sufficiently secured by individually controlling the coil couples, and high magnetic field strength, controllability, and operability can be improved. A sufficient space is secured around the patient by shaping the iron core of the iron-core coil like a C ring as shown in Figs. 7 and 8, by directing its magnetic pole toward the patient, and by disposing at least one coil around the patient while being used together with an apparatus, such as a fluoroscopic apparatus, and therefore a medical practice can be performed without being hindered by the existence of the iron-core coil. Additionally, a strong magnetic field can be generated in the direction of the body axis of the patient, and leakage flux can be reduced, and normal medical instruments can be used by applying magnetic shielding. If the patient is placed by independently using a C type arm, a magnetic field in a uniaxial direction can be generated, and a three-dimensional magnetic field can be generated by controlling the C type magnetic arm and by adjusting the angle and position of the C type magnetic arm. In a portable magnetic-field

generator shown in Figs. 9 and 10 in which a C-ring-shaped iron-core coil is attached to a supporting device so as to be able to rotate, move up and down, and expand and contract, since it has a simple structure, a medical practice that freely uses a magnetic apparatus can be performed in accordance with an existing medical instrument, a patient's state, the kind of medical manipulation, and timing. Additionally, if magnetic shielding is applied, the leakage flux can be reduced to a geomagnetic level, and the magnetic apparatus is widely applicable in the field of medical services. If an extendable structure that uses iron-core coils as shown in Figs. 11 and 12 is formed by fixing its iron core with a fixing screw when necessary so that a yoke can freely move, expand, and contract in the coil, general-purpose properties with respect to an instrument used together, a patient, a target, etc., can be improved while controlling the strength of and the range of a magnetic field that is generated in the patient's body. Additionally, if an extendable mechanism is formed so that a yoke that generates a magnetic force is contained in another cylindrical magnetic substance as shown in Figs. 13 and 14, the leakage flux that leaks to a surrounding area is more greatly reduced, and the leakage flux can be even more greatly reduced by reducing interference with peripheral machines or

with medical personnel. Additionally, if an arm type structure that supports the coil by a hinge structure is formed as shown in Fig. 15, the distance and the position with respect to the patient can be adjusted with a large degree of freedom, and a desired coil can be disposed as an adjustable arm at a desired position around the patient. The magnetic force of a magnetic-field generator shown in Fig. 16 that uses a ring-shaped iron-core coil is calculated as follows. Herein, let it be supposed that an N-turn exciting winding is attached to a C type magnetic yoke and is excited by electric current i . The magnetic path length of the C type yoke is designated as L_2 , the length of an air gap where a magnetic field is generated is designated as L_1 , the sectional area of the yoke is designated as S_1 , the sectional area of the air gap is designated as S_2 , and the relative permeability of the yoke is designated as μ . In an idea of a magnetic circuit, since the relationship among magnetomotive force V_m , magnetic flux ϕ , and magnetic reluctance R_m is expressed as

$$V_m = \phi \cdot R_m \quad (1),$$

magnetic flux ϕ to be generated can be calculated from magnetomotive force V_m and magnetic reluctance R_m . Since electric current i is passed through the N-turn winding, the magnetomotive force is $V_m = Ni$, and the magnetic reluctance is

divided into a yoke part and an air gap part and is calculated as follows. Herein, μ_0 is vacuum permeability.

$$R_m = L_1 / (\mu_0 \cdot \mu \cdot S_1) + L_2 / (\mu_0 \cdot S_2) \quad (2)$$

Therefrom, magnetic flux ϕ generated in the yoke and in the air gap part can be calculated as

$$\phi = V_m / R_m = N i / R_m \quad (3)$$

Therefore, since magnetic field H generated in the air gap part is

$$H = \phi / (\mu_0 \cdot S_2) \quad (4),$$

the following calculation can be made by substituting equations (2) and (3) for ϕ .

$$H = \frac{N i}{\frac{L_1}{\mu_0 \mu S_1} + \frac{L_2}{\mu_0 S_2}} \times \frac{1}{\mu_0 S_2}$$

If the length L_1 of the C type yoke is set at 5m, and the length L_2 of the air gap part (magnetic-field generation part) is set at 30cm in practice, the diameter of the C type yoke is about 1.6m on the supposition that the C type yoke is shaped like a circular arc. The sectional area of the yoke is set to be 50cm \times 50cm (0.25m²). When a 1200-turn coil is wound thereon and an electric current of 100A is passed therethrough, a magnetic field to be generated is about 40kA/m (= about 5kOe).

A magnetic torque that this magnetic field generates in a prismatic rare earth permanent magnet of $1\text{mm} \times 1\text{mm} \times 3\text{mm}$ that can be mounted on a small-diameter guide wire becomes equal to about $12\text{g} \cdot \text{cm}$. In a prismatic rare earth permanent magnet of $2.5\text{mm} \times 2.5\text{mm} \times 10\text{mm}$ that can be mounted on a large-diameter guide wire, about 20 times as large magnetic torque as the aforementioned one is generated, and it is possible to generate a magnetic torque sufficient for a medical operation.

Calculation condition			Calculation result	
Magnetic-field calculation	Sign			
Magnetic path length of yoke (m)	L_2	5		
Air gap length (m)	L_1	0.3	Magnetic field (A/m)	367614.3141
Relative permeability of yoke	μ	1000	Magnetic field (Oe)	4994.035785
Sectional area of yoke (m^2)	S_1	0.25		
Sectional area of air gap (m^2)	S_2	0.09		
Number of turns	N	1200		
Electric current (A)	i	100	Magnetic torque (Nm)	0.001192843
Vacuum permeability (H/m)	μ_0	0.000001256	Magnetic torque (kgcm)	0.011928429
			Magnetic torque (gcm)	11.92842942
Residual		1		

magnetization of magnet (T)					
Volume of magnet (m ³)		0.0000000003			

L_1 : Length of air gap where magnetic field is generated

L_2 : Magnetic path length of C type yoke

S_1 : Sectional area of yoke

S_2 : Sectional area of air gap

μ : Relative permeability of yoke

i : Electric current

[0006]

[Effects of the Invention] The apparatus of the invention can be used together with conventional CTs and fluoroscopic apparatuses, and is only slightly affected by the size of a patient's body, medical manipulation, and necessary instruments. The strength of and the generated range of a magnetic field can be freely determined, and the influence of the magnetic force on a surrounding area can be remarkably reduced to a geomagnetic level, and therefore the degree of freedom in use, in installation, and in adjustment can be remarkably increased. Medical equipment that employs magnetism can be easily used also in conventional medical manipulation, if necessary. Additionally, an increase in efficiency and a reduction in power consumption can be achieved,

and very high magnetic field strength can also be generated. Through these facts, it becomes possible to have the practical application of the magnetic apparatus including the magnetic driving in the field of medical services that has been impossible until now, and new medical manipulation is developed, and, in addition, highly advantageous, medical manipulation that has been difficult until now can be performed with greater ease, with higher accuracy, with higher effect, and with safety.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[Fig. 1] Front view of the ring A in which four coils in a single plane are arranged on the fixing ring.

[Fig. 2] Side view of the ring A in which four coils in a single plane are arranged on the fixing ring.

[Fig. 3] Front view of the apparatus in which the outsides of the iron cores of a plurality of coils are connected by a magnetic substance.

[Fig. 4] Side view of the apparatus in which the outsides of the iron cores of a plurality of coils are connected by a magnetic substance.

[Fig. 5] Side view of the apparatus in which iron-core coils facing each other are connected.

[Fig. 6] Front view of the apparatus in which iron-core coils

facing each other are connected.

[Fig. 7] Front view of the apparatus in which the iron core of the iron-core coil is shaped like a C ring and its magnetic pole is directed to the patient.

[Fig. 8] Side view of the apparatus in which the iron core of the iron-core coil is shaped like a C ring and its magnetic pole is directed to the patient.

[Fig. 9] Side view of the portable magnetic field generator in which a C-ring-shaped iron-core coil is attached to a supporting device.

[Fig. 10] Front view of the portable magnetic field generator in which a C-ring-shaped iron-core coil is attached to a supporting device.

[Fig. 11] Sectional view of the extendable mechanism in which a yoke in the coil is fixed by a fixing screw so as to be able to move, expand, and contract.

[Fig. 12] Front view of the extendable mechanism in which a yoke in the coil is fixed by a fixing screw so as to be able to move, expand, and contract.

[Fig. 13] Sectional view of the extendable mechanism in which the yoke that generates a magnetic force is contained by another cylindrical magnetic substance.

[Fig. 14] Front view of the extendable mechanism in which the

yoke that generates a magnetic force is contained by another cylindrical magnetic substance.

[Fig. 15] Arm type positioning mechanism that supports the coil by a hinge structure.

[Fig. 16] Side view of the C-ring-shaped iron-core coil

[Description of Symbols]

1-1 Coil

1-2 Fixing ring

1-3 Ring driving portion

1-4 Fixed handle

2-1 Coil

2-2 Fixing ring

2-3 Ring driving portion

2-4 Fixed handle

3-1 Coil

3-2 Magnetic substance

4-1 Coil

4-2 Magnetic substance

5-1 Coil

5-2 Magnetic substance

6-1 Coil

6-2 Magnetic substance

7-1 Iron-core coil

8-1 Iron-core coil
9-1 C ring iron-core coil
9-2 Spur gear
9-3 Pinion gear
9-4 Angle adjustment means
9-5 Spur gears
9-6 Pinion gear
9-7 Driving means
9-8 Spiral gear
9-9 Pinion gear
9-10 Pinion gear
9-11 Worm & worm wheel
9-12 Worm wheel
9-13 Worm gear
9-14 Counter weight
10-1 C-ring-shaped iron-core coil
10-2 Spur gear
10-3 Pinion gear
10-4 Counter weight
10-5 Spur gear
11-1 Yoke
11-2 Coil
11-3 Magnetic substance

11-4 Fixing screw

12-1 Yoke

12-2 Coil

12-3 Magnetic substance

12-4 Fixing screw

13-1 Yoke

13-2 Coil

13-3 Fixing screw

13-4 Magnetic substance

13-5 Handle

14-1 Yoke

14-2 Coil

14-3 Fixing screw

14-4 Magnetic substance

15-1 Yoke

15-2 Coil

15-3 Handle

15-4 Worm

15-5 Worm wheel

15-6 Worm wheel

15-7 Worm

15-8 Handle

L_1 Length of air gap where magnetic field is generated

L_2 Magnetic path length of C type yoke

S_1 Sectional area of yoke

S_2 Sectional area of air gap

μ Permeability of yoke

i Electric current ratio

N Number of turns of coil

Fig.1

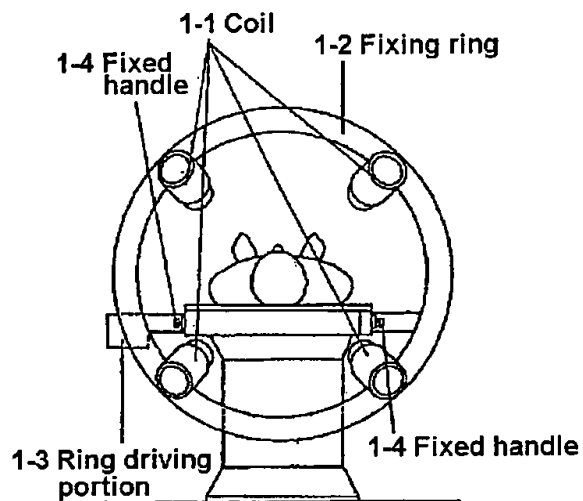


Fig.2

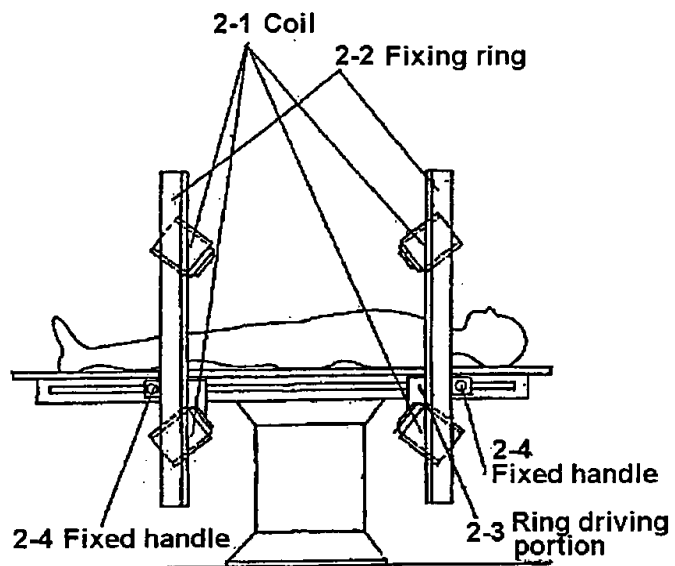


Fig.11

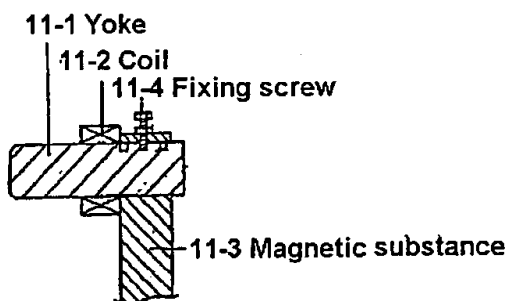


Fig.12

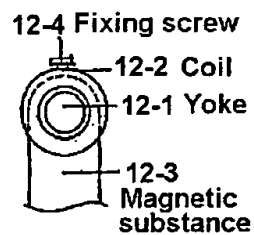


Fig.13

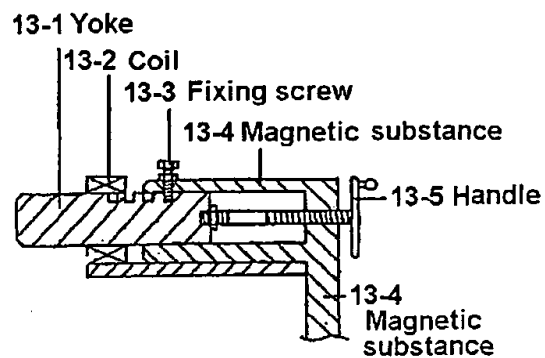


Fig.3

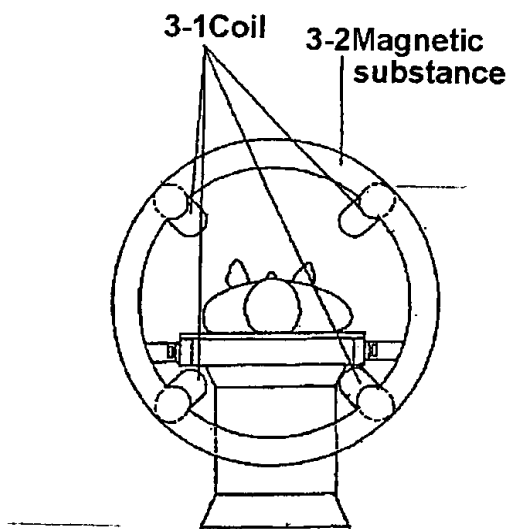


Fig.4

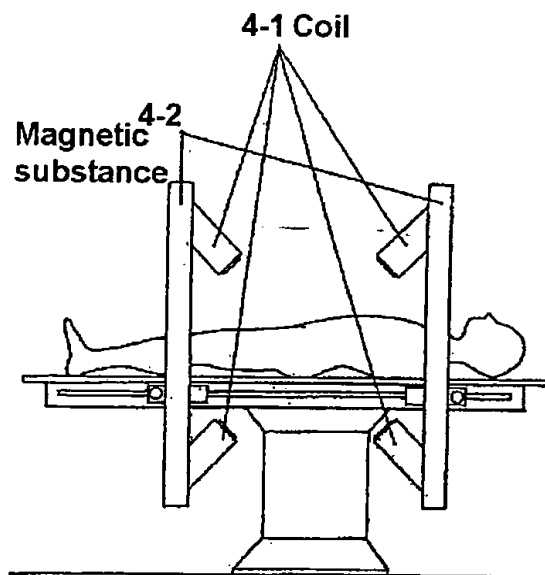


Fig.5

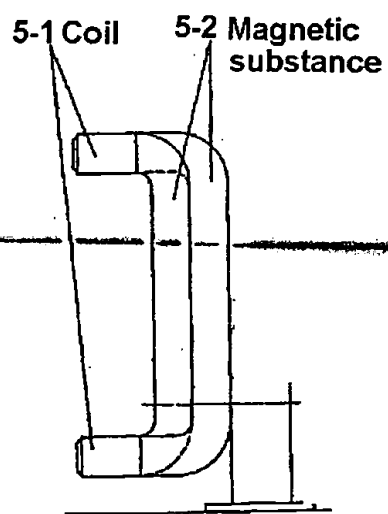


Fig.6

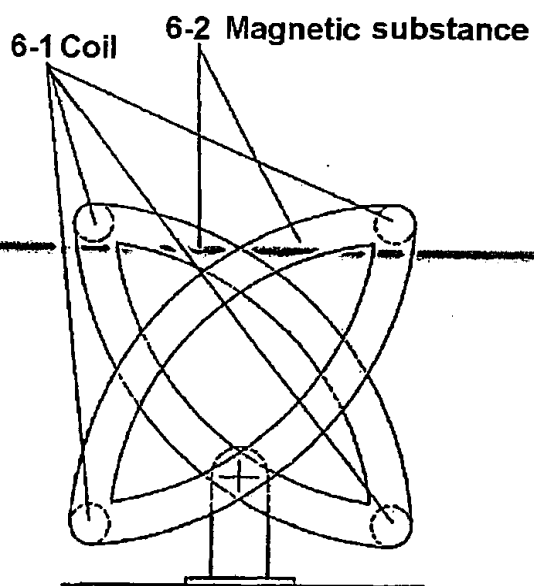


Fig.7

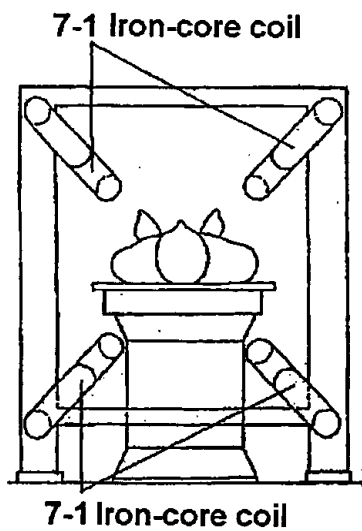


Fig.14

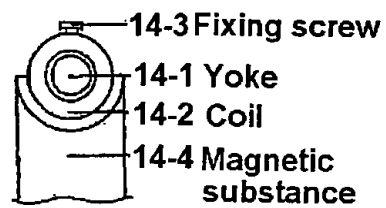


Fig.16

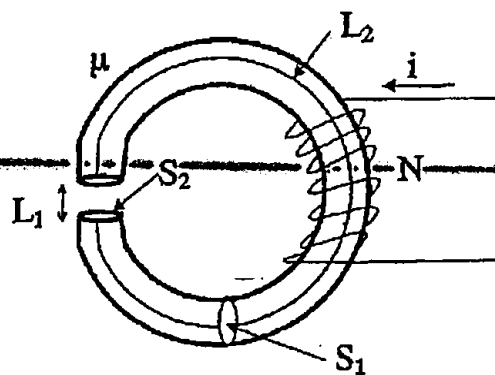


Fig.8

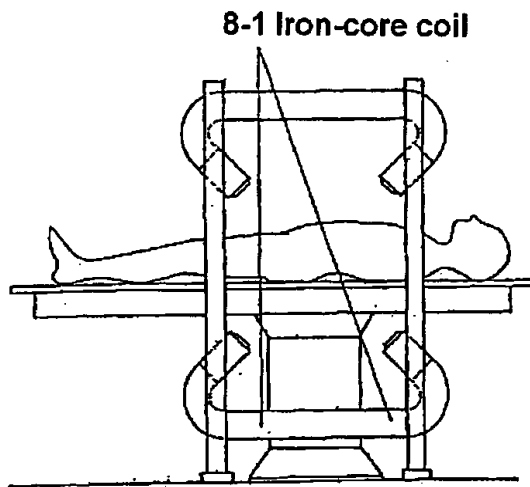


Fig.9

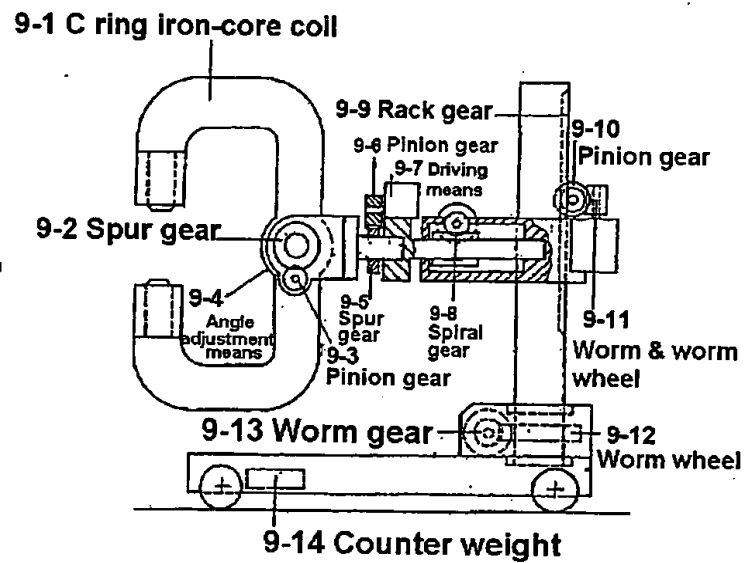


Fig.10

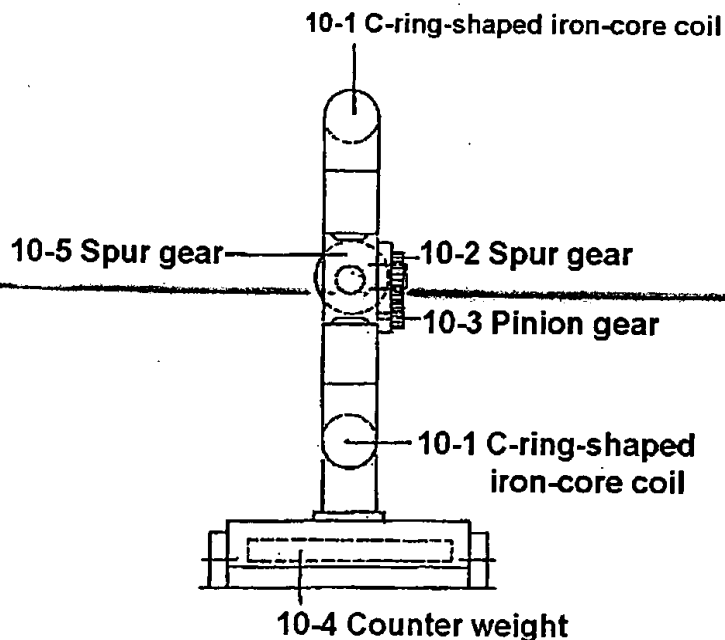


Fig.15

